Title: Tools and Training to Assess Profitability of Foliar Fungicide Use in Corn

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Abstract
Education and training materials were developed to assist growers in conducting on-farm corn foliar fungicide strip trials. Cooperators conducting fungicide strip trials during the 2012 growing season provided evaluation of web based educational materials developed for this project. Diagnostic support and hands-on corn foliar disease field workshops were offered to cooperators and others throughout NY State in order to boost confidence in identification of corn foliar diseases in the field. Data and observations collected and shared among a public-private network of cooperators as a result of the tools developed from this project will help build the knowledge base that will allow New York corn growers to make better-informed decisions about the use of foliar fungicides.

Background and Justification
Corn is an economically important crop in New York State with over one million acres planted annually. Grain corn which represents 55% of the acreage has averaged about $400 million from 2007-2011 while silage which represents 45% of the acreage has averaged $300 million during the same time period (2). Field corn, New York's most widely grown and highest net value crop, is impacted periodically by fungal leaf blights including gray leaf spot, northern leaf blight, northern leaf spot, eyespot, anthracnose leaf blight, and common rust. Leaf blights of corn can dramatically reduce yields and predispose plants to root and stalk rots. Management of leaf blights of corn in NYS include the use of adapted hybrids with resistance to prevalent diseases, rotational sequence and debris management, timely planting and harvest and plant stress reduction (managing soil fertility as well as insect and weed control).

Over the last five years an increasing trend in the use of strobilurin fungicides has occurred in the major Corn Belt areas of the U.S. for the purposes of controlling foliar diseases as well as "promoting" plant health. Recent research in the Midwest has indicated that there is no significant yield increase to justify the expense of increasing the use of foliar fungicides of corn in the absence of increased disease pressure (3). Although corn is a profitable crop in NYS, it requires a high level of expense to produce including costs associated with seed and fertilizers

and it is not known if multiple applications of strobilurin fungicides at tassel and silk will offer any economic benefit to NYS corn growers.

In 2010 and 2011, voluntary efforts were made by NYS cooperators including CCE extension personnel and NY corn growers to determine if the conclusions from the Midwestern studies of foliar fungicide applications and impact on corn yield would also be applicable to field corn in NYS. These informal studies consisted of establishing fungicide strip trials on NYS farms to collect data about disease incidence and severity and yield in non-treated and treated plots. However, there was little consistency in experimental design, data analysis across strip trials and cooperators expertise in disease identification varied. The development and deployment of a knowledge-based framework for assessing the benefits of foliar fungicide application to field corn in New York would allow New York corn growers to conduct statistically relevant fungicide strip trials in order to make better-informed decisions about the use of foliar fungicides.

In addition to aiding growers in making better-informed decisions about the economic benefit of corn foliar fungicides, there is also an indirect environmental benefit of this project. Decreased use of fungicides except when disease pressure is high should aid in decreasing selection for fungicide resistant strains of fungal pathogens. Strobilurins, the principal class of fungicides employed for plant health in corn, are classified by the Fungicide Resistance Action Committee (FRAC) as high risk for resistance development. Furthermore, strobilurins have been demonstrated to be toxic to several aquatic species in laboratory studies including frog tadpoles (1) and freshwater algae (4).

Objectives

1. Provide education, training, and diagnostic support that will enable public and private sector cooperators to conduct statistically appropriate strip trials with corn foliar fungicides.

2. Survey cooperators on impact of educational and technical support (Project Evaluation).

3. Communicate 2012 findings to cooperators and other stakeholder groups.

Procedures

1. Provide education, training, and diagnostic support that will enable public and private sector cooperators to conduct statistically appropriate strip trials with corn foliar fungicides.

Several education and training opportunities were developed and presented as part of this project. These consisted of a webinar presentation on corn foliar diseases, their control and conducting fungicide strip trials and two hands-on corn foliar disease identification field workshops, one held in the Southern tier and the other in Eastern NY State.

In addition to providing training opportunities, web education materials were also developed as part of this project. These web education materials consist of fact sheets on corn foliar diseases commonly found in NY State. These fact sheets were developed in both HTML as well as PDF format so that they are easy to download and print and were posted to the http://fieldcrops.org website which serves as a comprehensive one-stop website on all field crops related extension

materials in NY State. Fact sheets include information on disease prevalence in NY State, disease symptoms, conditions favoring disease, images and control methods. Two digital handouts developed for this project on conducting and analyzing corn foliar fungicide strip trials were also posted to http://fieldcrops.org. Finally, an updated table of the efficacy of corn foliar fungicides was also added to the website.

Diagnostic support was provided by the Cornell Field Crops Pathology Laboratory to fungicide strip trial cooperators and other extension educators as part of this project. Sample submission guidelines were provided so samples arrived in the best condition possible in order to ensure an accurate diagnosis.

2. Survey cooperators on impact of educational and technical support (Project Evaluation).

Cooperators that used the educational materials and technical support to aid in the setup and analysis of replicated corn foliar fungicide strip trials were asked to evaluate the educational materials provided in terms of increasing cooperator knowledge and confidence in establishing and collecting data from fungicide strip trials. An online survey was developed using the Qualtrix Cornell Survey Tool. Cooperators were emailed the link to the online survey and asked to complete it.

3. Communicate 2012 findings to cooperators and other stakeholder groups.

The education and training tools from this project were promoted to field crops extension educators during the weekly Field Crop IPM conference call. In addition, both the education and training tools as well as the results from strip trials conducted by cooperators in 2012 were presented at the "Improving Your Business With On-Farm Research" CCE meeting in Albany, NY on December 18, 2012 to 21 attendants. An article in the extension newsletter *What's Cropping Up?* about the education and training materials and strip trial results is planned for the March/April 2013 issue. This extension newsletter reaches over 150 subscribers in NY State and the Northeast region as well as many others through listserv distribution.

Results and Discussion

Corn Foliar Disease and Fungicide Strip Trial Webinar

A webinar was presented as part of this project by Dr. Gary Bergstrom to 19 participants during the weekly Field Crops IPM conference call on July 12, 2012. Information presented included: 1) common foliar diseases of corn in NY State, 2) control strategies for these diseases 3) data from studies on foliar fungicides for plant health and 4) how to conduct corn foliar fungicide strip trials. The presentation is posted online as a PDF at http://fieldcrops.org/Corn/Documents/CornFungicideBergstrom6.21.12.pdf.

The development of an online training module for the PMEP Distance Learning Program based on the information presented in this webinar is being planned.

Corn Foliar Disease Identification Field Workshops

In addition to the webinar presentation, two hands-on corn foliar disease identification field workshops were held. Both workshops were led by Dr. Gary Bergstrom. The tone of the workshops was informal without a specific agenda. Dr. Bergstrom helped participants identify diseases in the fields visited and then provided information about those diseases including disease cycle and how it relates to disease control. The two major goals of the corn foliar disease identification field workshops were 1) to increase participant confidence in identifying corn foliar diseases and 2) to familiarize participants with corn foliar fungicide strip trials and the available web education materials.

Figure 1. Common smut identified during a Corn Foliar Disease Identification Field Workshop in Chemung and Tioga counties August 21, 2012.

The first workshop was organized in collaboration with Mark Ochs of Ochs Consulting and took place in fields in both Tioga and Chemung Counties on August 21, 2012. Five participants visited no-till corn fields in four locations within these counties.

Gray Leaf Spot disease pressure is high in this area of the state due to its location in the Susquehanna River valley. Gray Leaf Spot was evident in all fields but little or no significant crop loss was expected due to properly timed fungicide applications. Other notable observations during this workshop were the extensive foliar and ear damage by birds in some of the fields as well as the discovery of dodder on the roadside as participants traveled from one field to the next. Common smut was also identified in a corn field in Chemung County (Figure 1). Occurrence of common smut was high throughout the state this growing season due to the dry weather conditions.

The second corn foliar disease identification field workshop was held in Hudson, NY in Columbia County on September 5, 2012 (Figure 2). This workshop was organized in collaboration with Alex Wright, Carolina Eastern-Vail, Inc. Sixteen participants consisting of crop consultants, growers and extension educators attended the workshop. Symptoms of Northern Corn Leaf Blight and Northern Corn Leaf Spot were identified. Participants were provided handouts on conducting corn foliar fungicide strip trials and directed to

Figure 2. Corn Foliar Disease Identification Field Workshop, September 5, 2012, Hudson, NY. Top photo: Dr. Gary Bergstrom discusses corn foliar disease identification and control with CCE educators, crop consultants and growers. Bottom photo: Dr. Gary Bergstrom examines a sample with potential stalk rot.

http://fieldcrops.org which houses the fact sheets on corn foliar diseases commonly found in NY State developed as part of this project.

Web Education Material Evaluation

Evaluation of web education materials to support on farm fungicide trials was conducted by three field crop extension educators: Keith Severson (CCE Cayuga), Joe Lawrence (CCE Lewis) and Kevin Ganoe (CCE Schoharie). All three extension educators were working with growers during the 2012 growing season to assist with setting up corn foliar fungicide strip trials and collecting data from the strip trials.

Survey Part 1: Conducting On-Farm Corn Foliar Disease Fungicide Strip Trials

Results from the three evaluations indicated that two-thirds of the respondents referenced the handout "Conducting On-Farm Corn Foliar Disease Fungicide Strip Trials" while helping growers set up their own strip trials this past growing season. The reason given for not referencing this document had to do with the fact that the cooperator had conducted fungicide strip trials for the past three years. One of the respondents that did reference the handout found it useful but had to expand the trial beyond three replicated strips because the grower wanted to add more treatments. Regardless of whether the handout was referenced or not when setting up fungicide strip trials, all three cooperators indicated that the handout contains enough instruction and background for someone to setup an on-farm fungicide strip trial. A suggestion to make the handout even more comprehensive was to add information on spatially balanced block design (What's Cropping Up?, Vol. 15, No. 1) to assist in developing more complex strip trials with multiple treatments. Another suggestion was to reference and link to the corn foliar disease fact sheets developed as part of this project.

Survey Part 2: Collecting Data for On-Farm Corn Foliar Fungicide Strip Trials

Only one out of the three cooperators evaluating the web education materials indicated that they used the handout "Collecting Data for On-Farm Corn Foliar Fungicide Strip Trials" to assist in collecting data from fungicide strip trials. The two cooperators that did not use this document indicated that it was because they were unaware that it was available. All cooperators agreed that the rating scale used to rate disease was easy to interpret and use. One comment about the data collection tables in this document was that it was limited to a treated vs. non-treated comparison only. If additional treatments are added then the number of columns in the table would need to be expanded.

Survey Part 3: Corn Foliar Disease Fact Sheets

The three cooperators were asked to review the corn foliar fact sheets developed as part of this project found at: http://fieldcrops.org/Corn/Pages/ManagingDiseases.aspx and indicate if there was sufficient information in the fact sheets to make preliminary disease identification. All three cooperators indicated that the fact sheets would be more than sufficient for this purpose. One cooperator commented: "The fact sheets nicely complete the package."

Diagnostic Support

Diagnostic support was provided by the Cornell Field Crops Pathology Laboratory at no charge to cooperators conducting fungicide strip trials as well as others including extension educators, crop consultants and growers during the 2012 growing season. Eighteen samples from seven counties were submitted for foliar disease identification (Figure 3). Disease identification results were relayed to submitters either via email or phone. Corn foliar diseases identified included Gray Leaf Spot, Northern Corn Leaf Blight, Northern Corn Leaf Spot, Common Rust and Giberella Ear Rot.

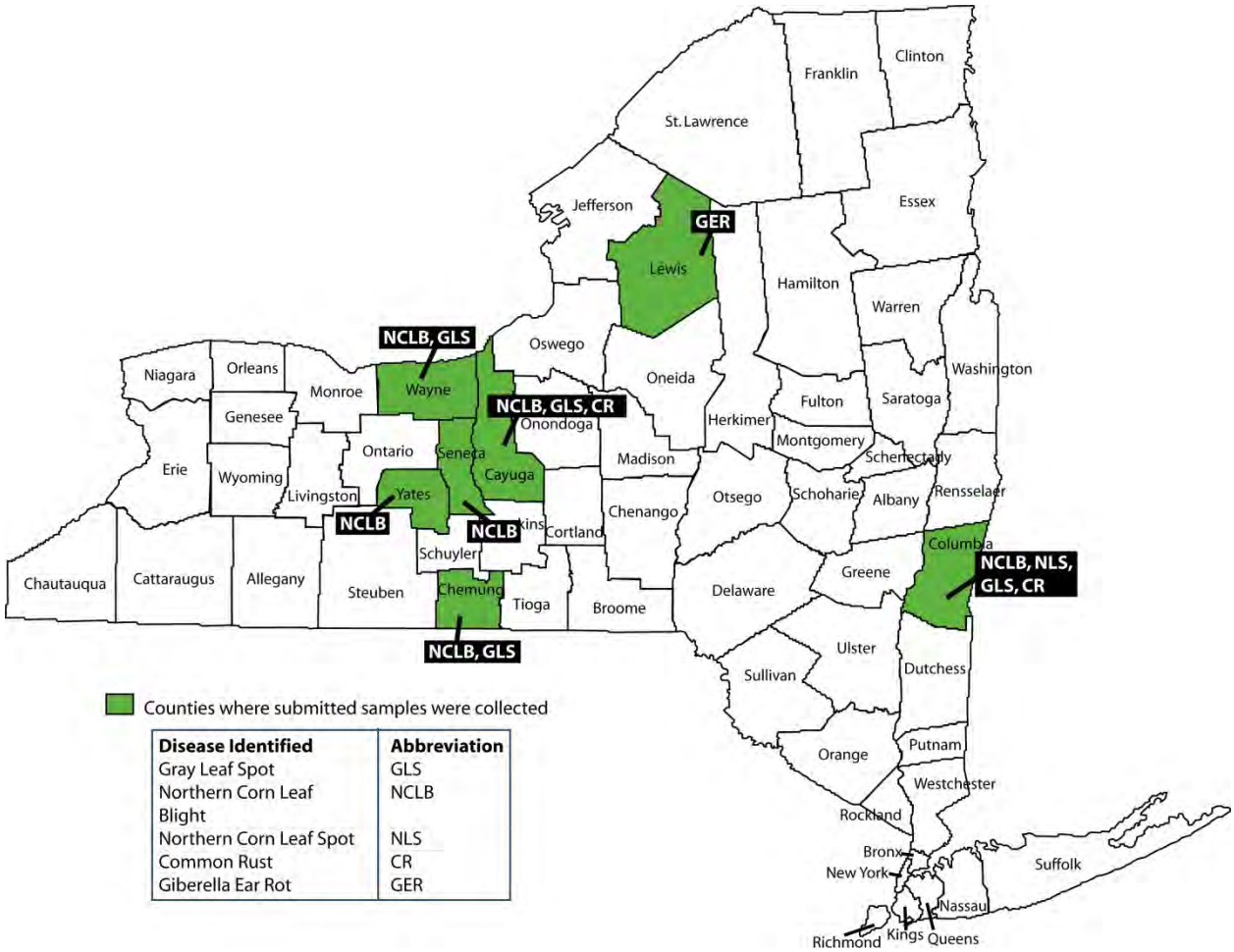

Figure 3. Counties where submitted samples were collected and diseases identified.

Summary

Three training opportunities on corn foliar diseases and conducting on-farm fungicide strip trials were conducted as part of this project. These training opportunities consisted of a webinar presented to extension educators during the Weekly Field Crops IPM Conference Call and two hands-on corn foliar disease identification field workshops, one held in the Southern tier and the other in Eastern NY State.

Evaluation of web education materials on conducting and collecting data on fungicide strip trials and corn foliar disease fact sheets developed as part of this project were favorable by cooperators that conducted fungicide strip trials in the 2012 growing season. Feedback from these evaluations indicated that the availability of the web education materials needs to be promoted more to appropriate targeted audiences. Potential future opportunities for promotion of these web education materials are in the extension newsletter *What's Cropping Up?*, on the NYS CCE Field Crops News blog and at NYS stakeholder meetings.

Informal communication with cooperators involved in this project indicated that confidence in identifying corn foliar diseases in the field is still low. Disease identification is a necessary part of data collection for fungicide strip trials and without it limited conclusions about appropriate control measures can be drawn. Although the evaluations did indicate that the disease fact sheets did provide sufficient detail through text and images to make a preliminary disease identification, future hands-on corn foliar disease identification workshops in other parts of the state may be warranted to help boost confidence in corn foliar disease identification and in turn encourage increased employment of fungicide strip trials.

Project Locations

Foliar Corn Disease Field Workshops

Foliar corn disease identification workshops were held in Chemung and Tioga County as well as in Columbia County.

Cooperator Coordinated Corn Foliar Fungicide Strip Trials

Educational materials developed for this project and disease diagnostic support were used to aid in the setup and analysis of replicated corn foliar fungicide strip trials in Cayuga County, Lewis County and Schoharie County.

Samples of Resources Developed

Electronic Resources

Corn Foliar Disease Fact Sheets (HTML and PDF versions) (See appendix 1 for an example fact sheet): http://fieldcrops.org/Corn/Pages/ManagingDiseases.aspx.

Efficacy of Fungicides for Corn Disease Control Based on Appropriate Application Timing: http://fieldcrops.org/Corn/Pages/ManagingDiseases.aspx#fungcorn

Foliar Fungicides for Corn in New York State Presentation (PDF): http://fieldcrops.org/Corn/Documents/CornFungicideBergstrom6.21.12.pdf

Conducting On-Farm Corn Foliar Fungicide Strip Trials (Appendix 2): http://fieldcrops.org/Corn/Documents/cornstriptrial2012.pdf

Collecting Data for On-Farm Corn Foliar Fungicide Strip Trials (Appendix 3): http://fieldcrops.org/Corn/Documents/cornstriptrial2012_data.pdf

Literature Cited

1. Belden, J., McMurry, S., Smith, L., and Reilley, P. 2010. Acute toxicity of fungicide formulations to amphibians at environmentally relevant concentrations. Environ. Toxicol. and Chem. 29:2477-2480.

2. New York Agricultural Statistics Service. U.S. Department of Agriculture. 2011. (NY NASS,2011).http://www.nass.usda.gov/Statistics_by_State/Ag_Overview/AgOverview_NY.pdf
3. Ochoa-Acuna, H. G., Bialkowski, W., Yale, G., and Hahn, L. 2009. Toxicity of soybean rust fungicides to freshwater algae and *Daphnia magna*. Ecotoxicology 18:440-446.
4. Wise, K. and Mueller, D. 2011. Are Fungicides No Longer Just For Fungi? An Analysis of Foliar Fungicide Use in Corn. APS*net* Features. doi:10.1094/APSnetFeature-2011-0531

Appendix 1. Example fact sheet: Gray Leaf Spot

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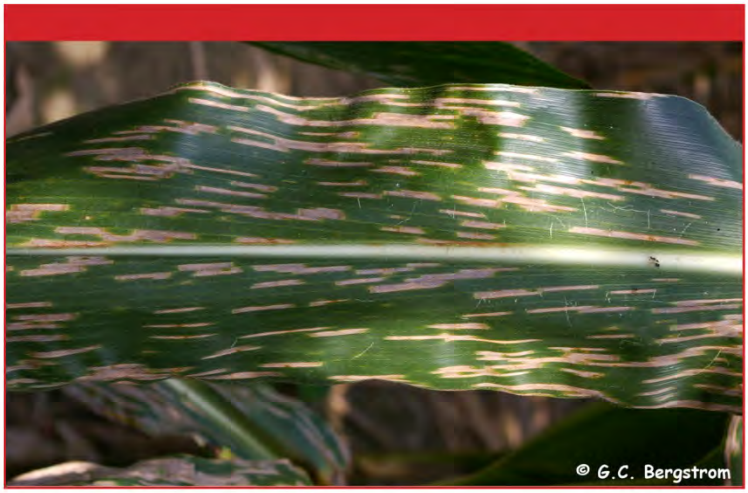


Gray Leaf Spot

Disease Facts

Gray leaf spot is caused by the fungus *Cercospora zeae-maydis*.

Epidemics of gray leaf spot have been observed in New York State in the Southern Tier and the Hudson River Valley. New hot spots of the disease have been reported in the Mohawk Valley and the Leatherstocking Region.

Gray leaf spot is favored by wet humid weather as often found in valley microclimates. Additionally, it is favoved in situations with reduced tillage and continuous corn.

Airborne spores are spread locally and regionally from corn debris.

Management Strategies

Management strategies for gray leaf spot include tillage, crop rotation and planting resistant hybrids.

Fungicides may be needed to prevent significant loss when plants are infected early and environmental conditions favor disease.

Symptoms

Symptoms of gray leaf spot are usually first noticed in the lower leaves.

Initially, lesions of gray leaf spot begin as a small dot with a yellow halo.

Lesions will elongate over time running parallel to the veins becoming pale brown to gray and rectangular in shape with blunt ends. These lesions can be described as having the appearance of a "matchstick."

Lesions may eventually coalesce killing the leaves.

Leaves appear grayish in color due to the presence of fungal spores.

Appendix 2. Conducting On-Farm Corn Foliar Strip Trials Handout

Cornell University

Conducting On-Farm Corn Foliar Fungicide Strip Trials

Local growing conditions, disease pressures and cropping practices can all impact the effectiveness and economic worth of foliar fungicides of corn. For this reason, it can be very useful for growers to conduct fungicide strip trials to determine the added value of foliar fungicides on their own fields. The following document outlines how to conduct a fungicide strip trial at flowering stages including data collection and disease assessment information.

Setting Up the Strip Trial

Your corn foliar fungicide strip trial should consist of at least three replicated paired strips of fungicide sprayed vs. non-sprayed (figure 1).

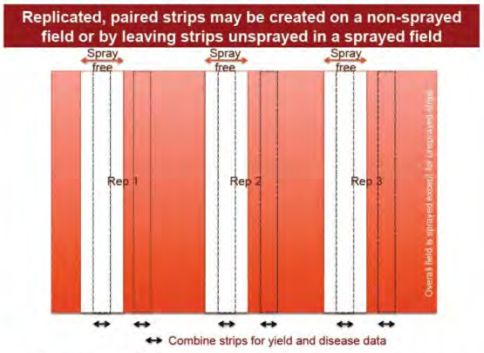


Figure 1. Recommended layout for fungicide strip trial. Note the three replicated paired strips.

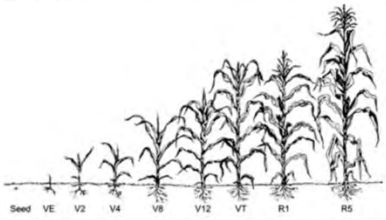
Having treated and non-treated strips paired helps ensure that differences in crop performance are due to treatment differences and not natural spatial variation.

It is important that at least three replicate paired strips be performed. Splitting a field (i.e. half treated and half non-treated) results in spatial variation that will mask real treatment differences

Target spray should be conducted at 50% tassel (VT, figure 2), but it could be sprayed earlier than this or as late as brown silk (R2). Fungicide applications should be made with either a high clearance sprayer or aerial applicator. Use spray volume minimums of 2-5 for aerial and 15 gal./acre for ground applications or as specified on the fungicide label.

Growing Season Monitoring

- Information about disease in both the treated and non-treated strips should be collected at spray time (VT-R2) and again at R5 stage.



Vegetative		Reproductive	
Stage	**Description**	**Stage**	**Description**
VE	Emergence	R1	Silking- silks visible outside of the husk
V1	One leaf with collar visible	R2	Blister- kernels are white and resemble a blister in shape
V2	Two leaves with collars visible	R3	Milk – kernels are yellow on the outside with a milky inner fluid
V(n)	(n) leaves with collars visible	R4	Dough – milky inner fluid thickens to a pasty consistency
VT	Last branch of tassel is completely visible	R5	Dent- nearly all kernels are denting

Figure 2. Corn growth stages. (Source http://extension.entm.purdue.edu/fieldcropsipm/corn-stages.php)

- Collect information on which diseases are present and the disease intensity.
- Disease intensity should be recorded for the canopy (rating scale 0-5) as illustrated in figure 3 as well as on the leaf corresponding to the lowest corn ear (rating scale 0-100%, figure 4).
- Inspect plants at three locations along each strip and record data. Average ratings for each strip and compute means for each spray treatment.
- Record field history, corn hybrid (and its disease ratings), planting dates and other relevant information on the data collection sheet.
- **Need help with disease identification?** Visit http://fieldcrops.org/Corn/Pages/ManagingDiseases.aspx for more information on the most common foliar diseases of corn found in New York State.

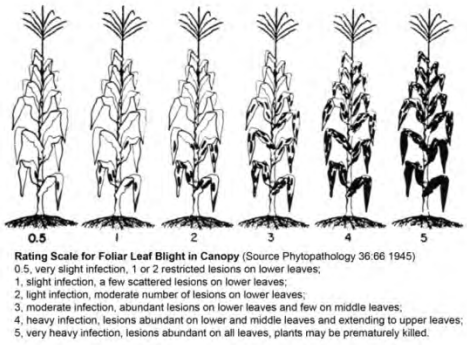


Figure 3. Rating scale for foliar leaf blight in canopy (Source Phytopathology 36:66 1945)

Harvesting the Strip Trial

- Yield determination should be conducted using a yield monitor or trooper scales.
- Measure moisture % of grain at harvest.
- Correct yield to standard 15% moisture content.

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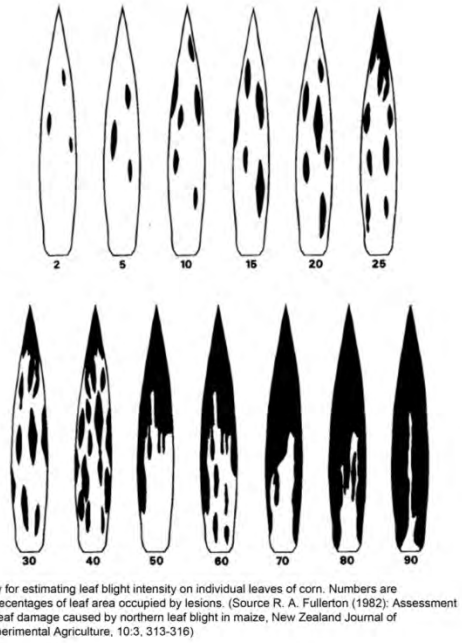

Figure 4. Key for estimating leaf blight intensity on individual leaves of corn. (Source R. A. Fullerton (1982): Assessment of leaf damage caused by northern leaf blight in maize, New Zealand Journal of Experimental Agriculture, 10:3, 313-316)

Appendix 3. On-Farm Corn Foliar Fungicide Strip Trials: Data Collection Handout

Corn Data to Collect at Fungicide Spray

Cooperator				
Experiment Location				
Growth Stage at Fungicide Application				
Date Fungicide Applied				
Date Disease Rated				
Treatment	**Replicate**	**Canopy Disease Intensity (0-5)**	**Ear Leaf Disease Severity (0-100%)**	**Disease(s) Present and Relative Amount, Other Notes**
Non-Sprayed	1			
Fungicide-Sprayed	1			
Non-Sprayed	2			
Fungicide-Sprayed	2			
Non-Sprayed	3			
Fungicide-Sprayed	3			

Corn Data to Collect About One Month After Fungicide Application

Cooperator	
Experiment Location	
Date R5	
% Milkline Progression	
Date Disease Rated	

Treatment	Replicate	Canopy Disease Intensity (0-5)	Ear Leaf Disease Severity (0-100%)	Disease(s) Present and Relative Amount, Other Notes
Non-Sprayed	1			
Fungicide-Sprayed	1			
Non-Sprayed	2			
Fungicide-Sprayed	2			
Non-Sprayed	3			
Fungicide-Sprayed	3			